Coastal Pollutant Remediation Program Stormwater BMP Operation, Maintenance, and Performance Evaluation

Review of Stormwater Treatment Systems Installed Between 2000 and 2004 Summary Report

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1. INTRODUCTION

Nonpoint source pollution from roadway runoff has long been recognized as a major source of impairment to coastal water quality in Massachusetts and throughout the nation. Roadway runoff can result in the closure of shellfish beds, degraded drinking water supplies, loss of eelgrass, and a variety of other impairments to inland and coastal water quality.

In order to assist communities in mitigating these impacts, the Massachusetts Executive Office of Environmental Affairs, through the Office of Coastal Zone Management (CZM), offers funding assistance to coastal municipalities through the Coastal Pollutant Remediation Program (CPR). These grants, which have provided over $5 million in funding support since 1996, can be used to assess NPS pollution sources from roadways, and to implement stormwater best management practices (BMPs) for treating runoff from paved surfaces.

While stormwater BMPs can be very effective in removing pollutants such as sediment, oil, grease, and bacteria from roadway runoff, these BMPs must be designed, installed, and maintained properly in order to ensure long term pollutant removal efficiencies. CZM periodically evaluates BMPs installed with CPR funding support to ensure that systems have been installed properly and are being maintained in accordance with operation and maintenance commitments of municipalities at the time each grant is awarded. The following summary report provides an overview of the most recent assessment of CPR funded projects conducted by the Horsley Witten Group, Inc. (HW) with funding from CZM. This summary report includes the assessment methodology developed by HW and CZM (section 2), a summary of inspection results and findings (section 3), and a set of recommendations for improved siting, design, and maintenance of stormwater BMPs (section 4).

2. EVALUATION METHODS AND APPROACH

Through a series of site visits and a data gathering exercise, HW conducted a comprehensive review and assessment of the operation and maintenance performance of 25 stormwater remediation projects funded through CPR between 2000 and 2004. Of these projects, 19 involved the installation of one or more stormwater BMPs (e.g. catchbasins, infiltration chamber, constructed wetlands, etc.). A total of 37 treatment systems, either single BMPs or treatment trains, were installed over the five year period. The review included an evaluation of the functionality of each system based on:

1) Siting, design, and construction of each system; and
2) Evidence of maintenance since installation.

In order to adequately assess each stormwater BMP, HW reviewed the available grant proposals and water quality treatment objectives for each project, as well as "as built" design plans prior to conducting field inspections.

Site inspections were conducted in the months of May and June, 2005. According to data obtained from the Massachusetts Department of Conservation and Recreation, precipitation amounts in the month of May were greater than normal when compared to historical data, while total precipitation for the month of June was less than the norm. Field inspection forms (Appendix A) were completed for each site, along with field narratives (Appendix B). These narratives give a step by step summary of the inspection. Findings and conclusions were developed by the inspector during each field inspection.

3. RESULTS

The most common stormwater management practice encountered during this assessment involved the collection of stormwater runoff by standard deep sump catchbasins (catchbasins equipped with added capacity for sediment storage), which are then connected to drainage manholes, oil/grit separators, or other pretreatment devices (devices intended to remove trash, coarse sediment, and floatable materials). Following passage through these devices, stormwater is fed to the final treatment structure and discharged or infiltrated. The majority of treatment practices includes some variation of underground leaching structure such as concrete leaching cylinders, chambers, vaults or synthetic polyethylene chambers or, in a few cases, constructed stormwater wetlands.

The table in Appendix C summarizes the results of the inspections of each of the 37 stormwater BMPs or treatment trains. The table includes the year the system was installed, the number and type of treatment systems installed during each project, design, construction, and maintenance issues found at each BMP, and recommendations for improving performance. Functionality of each system was rated using the following categories:

1) *Functional*: The system is operating as designed.
2) *Slightly impaired*: The system is operating near its intended capacity but requires maintenance or a minor repair.
3) *Severely impaired*: The system requires significant maintenance or repair and is providing marginal flood control and/or stormwater treatment.
4) *Non-functional*: The system has minimal flood storage and/or stormwater treatment capacity and needs to be redesigned or replaced.
5) *Unknown*: The system could not be evaluated due to access constraints.

Of the systems evaluated, 10 were rated as functional (27%), 12 were rated as slightly impaired (32%), 4 were severely impaired (11%), 10 were non functional (27%), and 1 could not be inspected (3%; table 1).

Table 1. Summary of the status and condition of evaluated systems

	functional	slightly impaired	severely impaired	not functional	unknown
number of systems	9	12	4	10	1
percentage of systems	27%	32%	11%	27%	3%

The most common causes of impairment were the buildup of sediment in stormwater collection and treatment devises (16 systems) and the lack of hoods on outlet pipes (14 systems). Other common sources of impairment and maintenance failures included paved-over manhole covers (6 systems), insufficient access to collection/treatment devices for various reasons (5 systems), or insufficient vegetative cover (2 sites). Stormwater BMPs were usually classified as non-functional due to compounded problems at each site, the most common of which were the siting of systems in high ground water/tidally influenced areas (7 sites) and/or installation of treatment devices outside of the primary stormwater flow line (i.e., stormwater runoff wasn't being effectively captured by the practice; 6 sites). Figure 2 provides an overview of the number of stormwater systems affected by each major type of impairment.

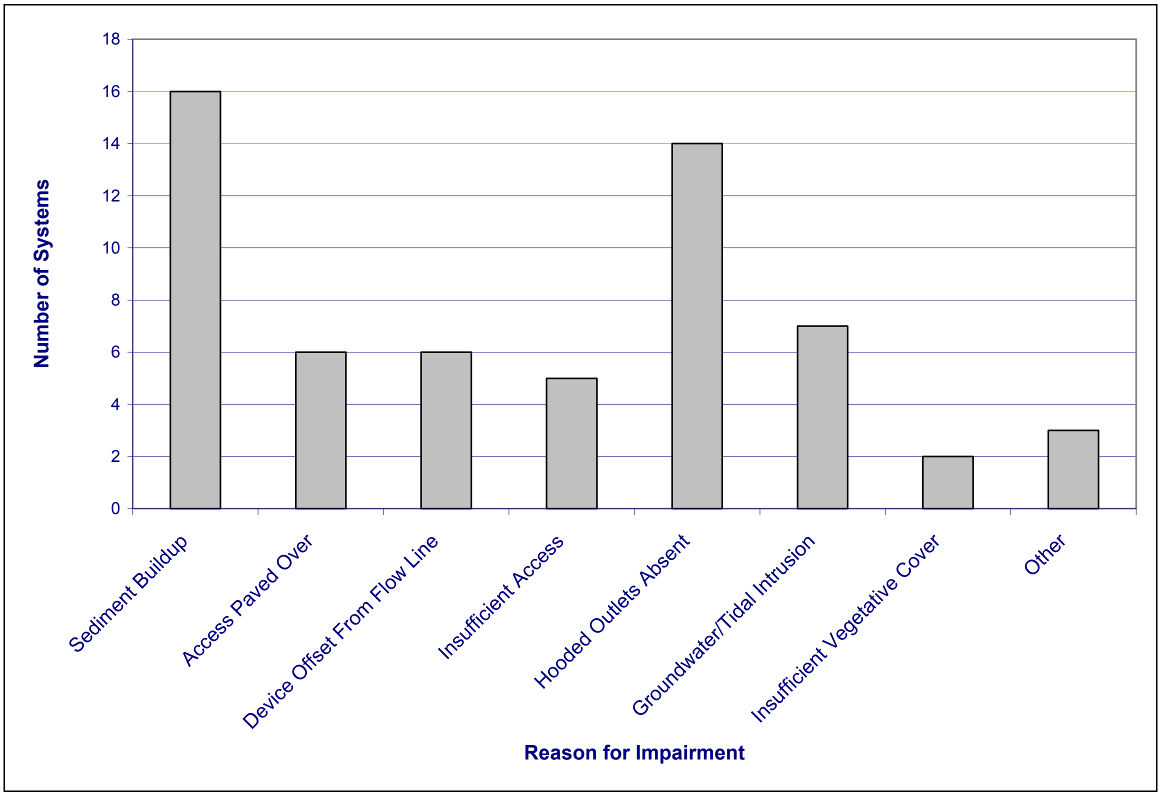

Figure 1. Causes of impairment to stormwater collection/treatment devices (note that some systems exhibit multiple causes of impairment)

During the course of each survey, HW also noted whether the system was likely to be in need of increased maintenance, usually the removal of accumulated sediments. Of the 37 systems inspected, 23 (62.16%) appeared to be in need of increased maintenance and 10 (27.03%) appeared to have been maintained adequately. Four systems were not included in the analysis due to the overall condition of the system (failed systems or systems that could not be evaluated). See Appendix C for an overview of inspection results.

4. CONCLUSIONS AND RECOMENDATIONS

This study resulted in three general conclusions:
1) Stormwater BMPs inspected during this assessment are not being adequately maintained: Results of field surveys indicated that almost two thirds of BMPs inspected were slightly or severely impaired due to inadequate maintenance. This situation likely extends to most stormwater conveyances and treatment systems within the municipalities surveyed. In order to ensure that these systems function properly, municipalities must make a commitment to the cleaning and removal of trash and sediment, and periodic inspections of each system. Municipalities must work to build adequate capacity to maintain their existing stormwater infrastructure.

2) Effective pretreatment of runoff is essential for the long term performance of underground infiltration systems. Observations at several sites revealed problems with underground systems that had failed or partially failed. Many of these systems were equipped with overflow structures and are likely to provide no more treatment than the system that was in place prior to implementation of the BMP. Without a diligent inspection and maintenance program, coupled with an effective pre-treatment system, the long-term pollutant removal capacity of each BMP will be jeopardized.

3) Underground systems are likely to receive less maintenance and inspection than surface systems. Many of the underground structures inspected through this study had not been inspected or maintained since construction was completed. To the extent possible, BMPs that are easily inspected and visible to town inspection and maintenance staff should be selected.

The following list of recommendations was developed in order to improve the long term performance of stormwater BMPs and is organized into three categories:

1) *Recommendations for improved maintenance*: improved design and management practices that facilitate more frequent and thorough maintenance.
2) *Recommendations for improved siting and design*: siting and design considerations that will enhance short and long-term stormwater collection, storage, and treatment capacity.
3) *Recommendations for improved construction practices*: practices that should be employed during and immediately following construction to ensure maximum flood storage and water quality treatment capacity.

These recommendations are based on data collected from the 37 site inspections performed under this project, experience from past inspections conducted by HW, and historical information and findings from outside sources. Table 2 provides a summary of all recommendations.

Table 2. Recommendations for improving stormwater BMPs

Recommendations for Improved Maintenance

1. Avoid installing underground stormwater systems within the travel lanes of a roadway.
2. Select surface stormwater BMPs over subsurface treatment systems.
3. Equip all recharge chamber fields and other BMPs with adequate access for cleaning and maintenance.
4. Install manhole risers and covers to grade.
5. Provide adequate access to the inlet and outlet control structures of all BMPs.
6. Design BMPs so that maintenance efforts can be focused on a smaller number of structures at a greater frequency

Recommendations for Improved Siting and Design

7. Equip all catch basins and water quality chambers with hoods at all outlet pipes.
8. Ensure that drainage collection structures are constructed in the stormwater flow line (i.e., stormwater runoff will be captured by the practice).
9. Incorporate flow diversion structures in system designs to bypass large storms around stormwater treatment systems.
10. Employ practices that provide stormwater collection and surface treatment prior to discharge in areas with shallow groundwater and/or tight soils (i.e. forebay, bioretention systems, swales, channels, constructed wetlands, etc.).
11. Employ surface stormwater practices in situations where the roadway grades are topographically too low to collect and convey stormwater to an underground infiltration system.
12. Install velocity dissipation devices (i.e. rip rap, and stilling basins) at all outfalls to reduce downstream erosion.

Recommendations for Improved Construction Practices

13. Remove all temporary erosion control devices following site stabilization.
14. Provide adequate time for vegetation to establish following construction of vegetated treatment devices.

4.1. Recommendations for Improved Maintenance of Stormwater BMPs

1. *Avoid installing underground stormwater systems within the travel lanes of a roadway.* Stormwater systems installed beneath roadways in high traffic areas require a police detail and/or traffic control plans in order for maintenance to be performed. These added safety considerations contribute to increased costs for maintenance activities, provide an added burden on the public works department, and may act as a deterrent to regular maintenance.

2. *Select surface stormwater BMPs over subsurface treatment systems*. The visual inspection of an underground BMP is much more difficult than inspection of surface practices. Unless the flood storage performance of a subsurface BMP is compromised, regular maintenance is often overlooked. Many underground practices are designed with overflow/bypass drainage features to accommodate higher flows. Once these systems fail, these bypass features become the primary stormwater conveyance, and water quality treatment benefits are quickly lost.

3. *Equip all recharge chamber fields and other BMPs with adequate access for cleaning and maintenance.* The standard recharge/leaching chamber design provides inspection ports for general inspection of the recharge chamber field. These inspection ports are installed to provide a visual inspection of the presence of standing water and/or clogging of sediment within the bottom of the chamber but do not provide adequate access for maintenance, equipment, and personnel. This type of design is prone to premature failure and offers no way to restore the function of the facility without complete re-construction.

4. *Install manhole risers and covers to grade.* For all leaching systems, the design should incorporate an access manhole with the rim extended to grade. For leaching systems in series, an access manhole should be provided for the first basin in series and at least one access manhole to every second leaching chamber thereafter.

5. *Provide adequate access to the inlet and outlet control structures of all BMPs*. Several underground BMPs were observed to have both inlet and outlet control structures that are completely inaccessible for maintenance, repair, or inspection. All BMPs, whether underground or at the surface, should have adequate access to inlet and outlet works to inspect, clean, and/or repair non-functioning systems. For underground systems, access should be provided by a manhole or vault with the riser rim and steps extended to the surface. Surface facilities should have an adequate maintenance road (at least 10 feet wide, with slopes less than 15%) for both the inlet and outlet control structures.

6. *Design BMPs so that maintenance efforts can be focused on a smaller number of structures at a greater frequency.* Many of the BMPs inspected during this project include several deep sump catchbasins that drain to an oil/grit separator and then into a leaching basin system. Effective maintenance of these systems requires the collection and removal of accumulated sediment and other debris from the catchbasins and oil/grit separator. Catchbasins have been shown to be moderately

effective in removing sediment (approximately 25-30% efficient at removing TSS) and then only when cleaned out frequently (usually 2 times per year is needed to obtain a 30% TSS removal efficiency (MADEP/CZM Stormwater Manual, 1997). Maintenance requirements for the stormwater system as a whole can be consolidated by installing one large sediment and debris collection chamber in place of several small sediment traps such as deep sump catchbasins. Installation of such a system can result in reduced maintenance requirements using less specialized equipment.

4.2. Recommendations for Improved Siting and Design

7. *Equip all catch basins and water quality chambers with hoods at all outlet pipes.* Where catchbasins and water quality chambers were equipped with hooded outlets, downstream sediment and debris deposition was limited in comparison to outlets without hoods. Hooded outlets minimize washout and help collect floatable pollutants and debris. Many municipal maintenance staff complain that hoods can be difficult to work around when cleaning basins or get broken during catchbasin cleaning operations. To lessen these concerns, designers should consider consolidating pretreatment in larger structures and should clearly note the maintenance requirements, procedures, and necessary equipment for sediment cleanout. Designs should incorporate hoods that can be easily removed prior to cleanout.

8. *Ensure that drainage collection structures are constructed in the stormwater flow line (i.e., stormwater runoff will be captured by the practice).* In several installations, drainage catchbasins were installed within a roadway system but were not correctly sited to adequately collect contributory drainage. BMP performance is first and foremost about capturing runoff. Designers must take great care to locate collection structures where runoff is currently being directed or to redesign the existing drainage pattern to direct stormwater flows to the appropriate collection point.

9. *Incorporate flow diversion structures in system designs to bypass large storms around stormwater treatment systems.* As stated previously, most if not all, CZM sponsored BMPs are being designed to retrofit existing pollutant concerns and are installed in space limited locations. Unless other design objectives warrant, larger storms should be designed to bypass these stormwater treatment systems. Large storms potentially contribute unwanted scour and excess debris that can compromise the long term pollutant removal efficiencies of stormwater BMPs. It is well documented that treatment of runoff from the one-inch storm will capture as much as 90% of the annual pollutant load to coastal Massachusetts.

10. *Employ practices that provide stormwater collection and surface treatment prior to discharge in areas with shallow groundwater and/or tight soils, (i.e. forebay, bioretention systems, swales, channels, constructed wetlands, etc.).* Several underground infiltration practices exhibited characteristics of premature failure. Some of these failures can be attributed to poor pretreatment, but most appear to be the result of high groundwater and/or poor soils. In situations where the depth to

groundwater is small (common in near shore and freshwater resource areas) and/or where testing reveals soils with low permeability (silts and clays), surface treatment BMPs should be selected. Pollutants such as sediment, bacteria, and nitrogen can be effectively managed by stormwater BMPs such as bioretention, constructed wetlands, water quality swales, and organic filters.

11. *Employ surface stormwater practices in situations where the roadway grades are topographically too low to collect and convey stormwater to an underground infiltration system.* As stated above, surface stormwater BMPs offer excellent pollutant removal capabilities for most pollutants and are a viable alternative to underground infiltration in sites with inadequate grades to direct flow or inadequate vertical separation to groundwater.

12. *Install velocity dissipation devices (i.e. rip rap and stilling basins) at all outfalls to reduce downstream erosion.* A few observations noted erosion at and below pipe outfalls from constructed BMPs. This erosion is generally easy to address with the proper design and inspection of velocity/energy dissipation practices. All outfalls, whether at the coast, near shore, or upland of resource areas, should be designed with a stabilized outfall consisting of adequately sized rip rap or other energy dissipation devices that will minimize erosion from the 2 and 10 year storms.

4.3. Recommendations for Improved Construction Practices

13. *Remove all temporary erosion control devices from the site following site stabilization.* A few of the project sites inspected retained the temporary erosion and sediment control measures, such as filter fabric and hay bales, that were originally installed for management of construction site sediment. The retention of temporary erosion control measures long after construction is a common problem for all development projects. Failure to remove these measures can contribute to long term performance impairments and premature failure of stormwater BMPs. Erosion and sediment control measures should be removed after construction is complete and vegetation is established.

14. *Provide adequate time for vegetation to establish following construction of vegetated treatment devices.* Many surface practices, most notably bioretention, water quality swales, and constructed stormwater wetlands rely on vegetation as a key component of the pollutant treatment process. These practices require adequate time during the growing season to establish vegetation and stabilize the BMP prior to the introduction of storm flowage. A few observations noted that vegetation was not adequately established before a practice was put into service.

5. IMPLICATIONS FOR THE CPR PROGRAM

The recommendations outlined above will be used to evaluate future CPR proposals and projects. Municipalities considering applying to the CPR program for funding are asked to demonstrate that these recommendations have been considered and incorporated into the planning and implementation process for stormwater mitigation efforts. CZM plans to conduct stormwater BMP assessments every five years and will use these assessments to make recommendations to towns for improving stormwater mitigation efforts. In addition, CZM will begin evaluating future funding requests based on operation and maintenance performance of past projects.

For more information on this summary report or the CPR program, please contact Jay Baker at jason.baker@state.ma.us.

Appendix A. Stormwater BMP Field Inspection Form

Stormwater Facilities Activation and Inventory Form

CPR Stormwater BMP Operation & Maintenance

A. Project Description

Location: Municipality:
Project/Technology: FY: Year Installed:

B. Facility Type

BMP Type: Inlet Structure:
Sediment Forebay or Trap: Outlet Structure:

C. General Inspection Information

Inspector: Tools:
Date of Inspection: Design Plan:
Weather: Asbuilt Plan:

Weather (Prior Two Weeks): Other: Date of Last Rainfall:

D. BMP Maintenance Evaluation circle one:
Notification of Maintenance from DPW: YES NO

Explain:
Evidence of Maintenance at Time of Inspection: YES NO
Explain:
Estimated Maintenance Period and Summary:

E. General Method (All BMPs)

No.	Item	Completed	Inspection Notes/Data/Findings
1	GPS Coordinates (Handheld GPS)		
2	General Condition of Surrounding Vegetation		
3	General Condition of Surrounding Roadway		
4	Vehicular Access from Public ROW (Ingress/egress)		
5	Inlet Structure(s) Condition		
6	Other Structure(s) incl. DMH, CB, DI, OWS, other		
7	Frames, Grates, Covers		
8	Riprap and Erosion Control Devices		
9	Concrete Condition		
10	General Erosion		
11	Structure obstructed by Objects (debris, sediment, etc.)		
12	Sediment Levels		
13	Notable Pedestrian Safely Issues (Hazardous Conditions)		

F. Specific BMP	
Type: Catch Basin	
Location:	Upstream Structure:
Total number:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
1	Frame and Grate		
2	Inlet and Outlet Condition		
3	Cracks or Other Displacements		
4	Joint Failure		
5	Loss of Joint Material		
6	Leaking		
7	Accumulation of Sediment, Trash, Debris		
8	Oil/Gas sheen on Water Surface		
9	Condition of Snout		
10	Other		

Type: Proprietary Device (Oil/Grit Separator)	
Location:	Upstream Structure:
Size:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
1	Frame and Grate		
2	Inlet and Outlet Condition		
3	Cracks or Other Displacements		
4	Joint Failure		
5	Loss of Joint Material		
6	Leaking		
7	Accumulation of Sediment, Trash, Debris		
8	Oil/Gas sheen on Water Surface		
9	Baffle Walls		
10	Other		

Type: Sediment Forebay	
Location:	Upstream Structure:
Size:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
1	Vegetation and Sideslope Condition (weeds, barren areas)		
2	Encroachment of Overgrown Vegetation into SW Facility		
3	Inlet and Outlet Condition		
4	Riprap or Other Erosion Control Devices		
5	Sediment Levels (greater than 50% design depth)		
6	Other		

Type: Infiltration Basin	
Location:	Upstream Structure:
Size:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
	Vegetation and Sideslope Condition (weeds, barren areas)		
	Encroachment of Overgrown Vegetation into SW Facility		
	Inlet and Outlet Condition		
	Riprap or Other Erosion Control Devices		
	Sediment Levels (greater than 50% design depth)		
	Surface Erosion		
	Overflow Structure Condition (evidence of use)		
	Ponding Water (clogging)		
	Evidence of Groundwater		
	Other		

Type: Infiltration Trench/Galley (Leaching Facility)	
Location:	Upstream Structure:
Total number:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
1	Frame and Cover or Inspection Port condition		
2	Infiltration Surface Condition		
3	Inlet and Outlet Condition		
4	Overflow Structure		
5	Structural Instabilities		
6	Cracks or Other Displacements		

7	Joint Failure		
8	Loss of Joint Material		
9	Standing Water		
10	Accumulation of Sediment, Trash, Debris		
11	Evidence of Oil or Gas		
12	Other		

Type: Vegetated Swale	
Location:	Upstream Structure:
Size:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
	Vegetation and Sideslope Condition (weeds, barren areas)		
	Encroachment of Overgrown Vegetation into SW Facility		
	Inlet and Outlet Condition		
	Riprap or Other Erosion Control Devices		
	Surface Erosion		
	Sediment Levels		
	Overflow Structure Condition (evidence of use)		
	Ponding Water (clogging)		
	Evidence of Groundwater		
	Check Dam Condition		
	Other		

Type: Constructed Wetland	
Location:	Upstream Structure:
Size & # Cells:	Downstream Structure:

No.	Item	Completed	Inspection Notes/Data/Findings
	Vegetation and Sideslope Condition (weeds, barren areas)		
	Encroachment of Overgrown Vegetation into SW Facility		
	Evidence of Invasive Species		
	Condition of Landscape Vegetation & Wetland Species		
	Evidence of Wildlife		
	Eutrophication Level of the Wetland		

	Inlet and Outlet Condition		
	Riprap or Other Erosion Control Devices		
	Surface Erosion		
	Sediment Levels		
	Overflow Structure Condition (evidence of use)		
	Condition of Water Cells (Design water levels)		
	Condition of Design berms & flow path through facility		
	Check Dam Condition		
	Other		

F. Inspector's Summary - General Notes and Recommendations

Appendix B: Sample Field Narrative

Wellfleet FY04 – Duck Creek

Date: June 17, 2005
Weather: Partly sunny, high 60s
Weather (Prior two Weeks): Two rain storm events over past two weeks

Description

The Wellfleet FY04 grant included two sites located in Wellfleet, MA. Both sites previously discharged untreated stormwater to Duck Creek (see Figure 3.66).

The first site was located within East Commercial Street, east of the intersection with Whil's Lane. The drainage system at this site included the installation of two new catchbasins, two leaching pits, and altering an existing corrugated metal drain pipe to divert runoff from the existing drainage system into the leaching pits (see Figure 3.67).

The second site was located within Railroad Avenue, between the intersection of Railroad Avenue and Commercial Street and the intersection with Railroad Avenue and Circuit Avenue. The concept proposed the installation of two new catchbasins and two new leaching pits (see Figure 3.68).

Findings

Both sites were constructed in conformance with the proposed plan that was issued as part of the grant application. At the time of the inspection both sites appeared to be functioning properly and neither system was backing stormwater up into the drainage system, which would be a sign that the system has been clogged from sediment load or debris.

During the inspection at Site 1, the covers and grates to the drainage system could not be removed due to high traffic volumes along East Commercial Street. The inspection was conducted visually into the catchbasins only. Both catchbasins were equipped with hoods on the outlet pipes. There were visible oil sheens and traces of floatables on the water surface within the catchbasins and a small amount of sediment at the bottom of the basins. The standing water was at the outlet inverts to the leaching facility. Due to the age of the treatment system, the adequacy of the maintenance schedule could not be determined.

The traffic volume was less at site 2, allowing grates and covers to be removed during the inspection. Both catchbasins were equipped with hoods on the outlet pipes. There were visible oil sheens and traces of floatables on the water surface within the catchbasins and a small amount of sediment at the bottom of the basins. The standing water was at the outlet inverts to the leaching facility.

Both systems appear to be sized properly, since the waterlines within the discharge structures are visible and are not over exceeding the structure volume capacity for either system. All grates, covers and components appear to be structurally sound and free from cracking. Sediment was found within the catchbasins but this is a sign the catchbasins are trapping sediment and floatable debris properly. However, maintenance is recommended.

Recommended Actions and Conclusions

Monitor maintenance schedule

Appendix C: Summary of Site Inspections and Recommendations for Each Stormwater Treatment System

Project	Site	Device	Design comment	Maintenance Comment	Functionality Comment	Recommended actions	Increase Maintenance?
1	1.1	water quality chambers; infiltration chambers	designed properly	manholes sealed with pavement	functional	clear paved-over manholes	yes
	1.2	deep sump manhole; water quality chambers	sized properly; no hooded outlet on deep sump manhole	sediment buildup in sump	slightly impaired	install hooded outlet; consider adding water quality chamber for pretreatment	yes
2	2.1	deep sump catchbasins; leaching pits	offset from gutterline	manholes sealed with pavement; sediment levels in catchbasins very high; oil residue in leaching pits	severely impaired	install collection structure in stormwater flow line	yes
	2.2	deep sump catchbasins; leaching pits	offset from stormwater flow line; sediment in leaching pit due to catchbasin washout	washout evident; sediment levels in catchbasins very high; oil residue in leaching pits	severely impaired	install collection structure in stormwater flow line	yes
3	3.1	catchbasin; proprietary water quality chamber	hooded outlet and sump absent in catchbasin; no access to proprietary water quality chamber	——	unknown	install or locate access ports	yes
	3.2	deep sump catchbasins; proprietary water quality chamber; infiltration chamber field	no hooded outlets; no inspection ports at infiltration chambers	catchbasins full of sediment and debris	slightly impaired	add hooded outlets; add inspection ports	yes
4	4.1	Catchbasins; constructed wetland	outlet pipe into wetland sediment forebay partially submerged	temporary erosion control structures remain at the site	slightly impaired	remove erosion control devices	yes
	4.2	catchbasins, constructed wetland	ponded water in wetland backs up into outlet pipe; no storm control between forebay and wetland	sediment buildup in forebay	slightly impaired	add storm control device	yes

Project	Site	Device	Design comment	Maintenance Comment	Functionality Comment	Recommended actions	Increase Maintenance?
5	5.1	deep sump manholes; water quality chambers	infiltration chambers sited in high groundwater and tight soils; hooded outlets absent	significant sediment in catchbasins; water ponded in infiltration chambers	non-functional	add hoods to all outlet pipes	NA
6	6.1	catchbasins; vegetated swale	see maintenance comment	manhole covers paved over; oil sheen and sediment evident on portions of the swale, inadequate vegetation evident on portions, while other sections are overgrown and covered with downed trees	severely impaired	Ensure swale is properly vegetated and maintained and has proper access for maintenance	yes
	6.2	catchbasins; micro pool; wet pond; constructed marsh	designed properly, but may be groundwater influenced	central catchbasins full of sediment to the outlet invert	slightly impaired	———	yes
7	7.1	catchbasin; leaching chamber	catchbasins not installed in primary stormwater flow-line; no access to leaching chamber; hooded outlets absent	catchbasins full of sediment	non-functional	install hooded outlets; raise manhole risers to grade; reposition catchbasins in stormwater flow line	yes
	7.2	catchbasin; leaching chamber	catchbasins not installed in stormwater flow-line; no access to leaching chamber; hooded outlets absent	catchbasins full of sediment	non-functional	install hooded outlets; raise manhole risers to grade; reposition catchbasins in stormwater flow line	yes
8	8.1	deep sump catchbasins; leaching catchbasin	hooded outlets absent	———	functional	install hooded outlets	no

Project	Site	Device	Design comment	Maintenance Comment	Functionality Comment	Recommended actions	Increase Maintenance?
8	8.2	vegetated filter strip; drainage trench	see maintenance comment	severe erosion and lack of vegetation evident	non-functional	revegetate BMPs	yes
	8.3	catchbasins; baffle tank; perforated pipe	hooded outlets absent; groundwater infiltration apparent		non-functional	install hooded outlets	yes
9	9.1	catchbasins; constructed wetlands	see maintenance comment	catchbasins full of sediment causing wetland to receive little water; evidence of excessive eutrophication	severely impaired	clean catchbasins; increase street sweeping	yes
10	10.1	deep sump manholes; water quality chambers	infiltration chambers sited in high groundwater and tight soils; hooded outlets absent	significant sediment in catchbasins; water ponded in infiltration chambers	non- functional	add hooded outlets to all outlet pipes	NA
11	11.1	catchbasins; leaching chambers	leaching chambers sited in high groundwater; hooded outlets absent	_____	non- functional	add hoods to all outlet pipes	yes
	11.2	catchbasins; leaching chambers	leaching chambers sited in high groundwater; hooded outlets absent	_____	non-functional	add hoods to all outlet pipes	yes
12	12.1	catchbasin; proprietary water quality chambers; proprietary infiltration chambers	hooded outlets absent; proprietary treatment and infiltration chambers lack surface access	_____	slightly impaired	install hooded outlets	no
	12.2	catchbasin; proprietary water quality chambers; proprietary infiltration chambers	hooded outlets absent; proprietary treatment and infiltration chambers lack surface access	_____	slightly impaired	install hooded outlets	no
	12.3	catchbasin; proprietary water quality chambers; proprietary infiltration chambers	hooded outlets absent; proprietary treatment and infiltration chambers lack surface access	_____	slightly impaired	install hooded outlets	no

Project	Site	Device	Design comment	Maintenance Comment	Functionality Comment	Recommended actions	Increase Maintenance?
13	13.1	catchbasins; leaching pits	see maintenance comment	leaching pits could not be inspected due to their installation under a high traffic roadway	functional	_____	no
14	14.1	deep sump catchbasins; leaching pits	hooded outlets absent	catchbasin contains 12" to 24" sediment	slightly impaired	install hooded outlets	yes
	14.2	catchbasins; weir; leaching field	hooded outlets absent in some outlet pipes; evidence of tidal influence	weir wall failing; grates over catchbasins paved over	not functional	install hooded outlets; reconstruct weir wall	yes
	14.3	deep sump catchbasins; leaching field	hooded outlets absent	catchbasins contains 12" to 24" of sediment	slightly impaired	install hooded outlets	yes
15	15.1	deep sump catchbasin; water quality chambers; infiltration chambers	road grade insufficient to collect and discharge stormwater; evidence of groundwater or clogged outlets in leaching chambers; stormwater bypasses part of the drainage system and discharges directly to a pond	sediment plume observed extending 30 to 40 feet into the resource area	non- functional	redesign stormwater system	N/A
	15.2	catchbasins; water quality chambers; infiltration chambers	system appears to divert the first flush	_____	non- functional	_____	N/A
	15.3	catchbasins; water quality chambers, infiltration chambers	see maintenance comment	covers of catchbasins and water quality chambers sealed with pavement; some catchbasins installed outside of stormwater flow line	slightly impaired	install catchbasins within stormwater flow lines	yes

Project	Site	Device	Design comment	Maintenance Comment	Functionality Comment	Recommended actions	Increase Maintenance?
15	15.4	deep sump catchbasins; water quality chamber; infiltration chambers	designed properly	maintained properly	functional	_____	no
16	16.1	catchbasins; proprietary treatment device; sand filter	designed properly	catchbasins maintained properly; equipment for sand filter maintenance not available	functional	Increase maintenance schedule for sand filter only	yes
17	17.1	deep sump catchbasins; water quality chamber; leaching pits	hooded outlets absent; one catchbasin discharges directly to leaching pit causing discharge of sediment, oil, and grease	_____	slightly impaired	_____	yes
	17.2	deep sump catchbasins, water quality chamber, leaching pits	hooded outlets absent; road berm causes bypass of catchbasins	significant sediment in water quality chamber	slightly impaired	install hooded outlets; install collection devices in stormwater flow line; improve pretreatment prior to discharge to water quality chambers	yes
18	18.1	catchbasins; proprietary stormwater treatment devices; recharge chambers	evidence of clogging in infiltration chambers or groundwater intrusion; recharge system may be undersized`	_____	slightly impaired	monitor system to determine whether infiltration is occurring; add velocity dissipaters to outfall	yes
19	19.1	catchbasins; leaching pits	access ports sited in high traffic area	_____	functional	_____	no
	19.2	catchbasins; leaching pits	_____	_____	functional	_____	no